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# Direct Reading Exposure Assessment Methods for Isocyanates: Current Options and Future Needs

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## Topics

- Why are direct-reading exposure assessment methods (DREAM) useful for MDI & TDI?
- Current DREAM options for diisocyanates
- Future needs in DREAM for diisocyanates



# Why are DREAM Useful for MDI & TDI?



# What are Isocyanates?

- “Isocyanates” refers to compounds containing the isocyanate functional group (-NCO).
- Commonly, the term is used to describe commercially important diisocyanate monomers used in the production of various polyurethanes.
- Toluene diisocyanate (TDI) and diphenylmethane diisocyanate (MDI) are the diisocyanates that Dow sells to customers who make polyurethane products:
  - Flexible foams (e.g., bedding and seat cushions)
  - Rigid foams (e.g., insulation)
  - Elastomers and coatings (e.g., footwear & automotive components)



## Why DREAM for MDI & TDI?

- Primary effect of inhalation over-exposure: respiratory sensitization and occupational asthma
    - Evidence supports 20 ppb ceiling / STEL as protective for prevention of respiratory sensitization
    - Toxicology suggests avoidance of brief high peak exposures important
- ➔ Rapid, in-field indication of such situations for workers is important



# Current DREAM Options for MDI & TDI



## Current DREAM Options for MDI & TDI

- Demands on DREAMs for MDI & TDI
  - Low (ppb) Exposure Guidelines
  - Reactive species (+/-)
  - Aerosol vs. vapor (MDI)



### Current DREAM Options for MDI & TDI (con't)

- *Colorimetric Methods*
  - Reaction with colorimetric reagent coated on paper tape, plastic film substrate
  - Orange / red color develops; read by visual color comparator or photodiode
  - Pro:
    - » Fairly sensitive (1 ppb) and specific
    - » Cost reasonable
  - Con:
    - » Some cross-sensitivities (e.g., NO<sub>x</sub>)
    - » Doesn't differentiate between different isocyanates
    - » Responds to color density; dirt, high humidity will register
    - » Shelf life limited – refrigerated storage required



## Colorimetric DREAM Devices

- Instruments —
  - Air pumped through paper tape (reel)
  - Hand-held or stationary
  - Numerical display, alarms & datalogging
  - 30 sec to 4-min sampling time



## Colorimetric DREAM Devices

- Dosimeter Badges —
  - Diffusive sampling using paper / polymer patch
  - Qualitative / semi-quantitative (comparator)
  - 15 min exposure needed to read 20 ppb



### Current DREAM Options for MDI & TDI (con't)

- *Non-colorimetric Methods: IMS (Ion Mobility Spectrometry)*
  - Ni<sup>63</sup> ionization, TOF-type MS detection
  - Pro:
    - » Sensitive and specific
    - » Rapid response
    - » Compact
  - Con:
    - » Expensive
    - » Ni<sup>63</sup> Source may pose travel problems
    - » Little industry experience with it yet





# Future DREAM Needs for MDI & TDI



## Future DREAM Needs for MDI & TDI

- **Key need:** Exposure Profiling
  - Short-term peak measurements
    - » Smallest time increment possible
    - » High sensitivity
    - » Rapid recovery
  - Data-logging
  - Compatible with video exposure assessment
    - » Time stamp
    - » Software for easy synchronization
  - Easily worn by worker



### Future DREAM Needs for MDI & TDI (con't)

- Sensitivity & Specificity
  - 0.1 ppb to accomodate possible lower OELs
  - Differentiate TDI, MDI from other isocyanate-containing species (e.g., aliphatic isocyanates (HDI, IPDI), oligomers, methyl isocyanate, isocyanic acid)
  - Accurate readings of isocyanate-containing aerosols
  - Absence of environmental effects (dust, humidity, NOx interference)
  - Accuracy +/- 25% min



### Future DREAM Needs for MDI & TDI (con't)

- Device requirements
  - Lightweight (< 3 lbs [1.4 kg])
  - Worker-wearable without interference in tasks
  - Battery powered (minimum 8-hr run time)
  - User-adjustable alarm points (including no alarm option)
  - Flexible, user-friendly data download software compatible with standard software (e.g., Excel)
  - UL-approved, intrinsically safe
  - Consumables shelf-life > 6 months
  - “Reasonable” cost



## Hurdles for New DREAM Development

- Market size vs. development cost
  - DREAM very useful to isocyanate and polyurethane producers
  - Technical demands for isocyanate DREAM high
  - Market small compared to other more general DREAM uses
- How the isocyanate industry can help:
  - Laboratory evaluation of new devices
  - Field evaluation of new devices